# SUSTAINABLE PATTERSON

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*forging a sustainable future*

# Executive Summary

The Patterson School Foundation (TPSF) is a nonprofit organization located in Happy Valley, North Carolina. Originally, the Patterson School Foundation operated as a teaching school and farm (The Patterson School Foundation [TPSF], 2015a). However, they were forced to discontinue their educational mission in 2009 due to economic difficulties. The Patterson School has partnered with the Nicholas School of the Environment to gain insight regarding development opportunities for their property. Specifically, the Patterson School Foundation has requested an analysis of their property that would investigate the land's potential for economic and sustainable development. Potential projects must be economical in order to avoid selling parts of their property as debt service. The request for sustainability stems from the Patterson School's commitment to environmental stewardship (TPSF, 2015b).

Our team sought to find recommendations that would utilize the preexisting resources at the Patterson School. The foundation has large amounts of land available for development and multiple existing buildings that are currently underutilized. Solutions that could more effectively utilize these resources include renewable energy development and transformation of the school into a sustainability destination.

Due to the large amount of land resources available, our team was immediately attracted to renewable energies as a development strategy. However, our research uncovered many possible complications for these projects. First, large-scale solar is not an ideal project for the Patterson School. Large-scale solar energy development would require a large section of land to be dedicated to renewable energy development for multiple decades. The Patterson School is currently not comfortable setting aside large tracts of land for such a long period of time. Similarly, large-scale wind is also not feasible for the Patterson School. The North Carolina Mountain Ridge Protection Act prevents the development of wind turbines larger than 100 feet in height from being developed on mountain ridges (North Carolina General Assembally [NCGA], 1983). This greatly limits wind power development on mountain ridges, where wind speeds are highest.

However, to keep with the sustainability requirement of our task we decided to further investigate small-scale wind and solar development at the Patterson School. We created wind and solar models to provide insight for their decision-making process. Data for the wind model was gathered from the Hickory Regional Airport, which served as a proxy location for the Patterson School. Three years of wind data was analyzed and the observed distribution was used to construct a wind power model. The solar analysis was conducted primarily by using PVWatts, a tool created by the National Renewable Energy Laboratory. The analyses of small-scale wind and solar were revealed to be uneconomic options in isolation. Both the wind turbine and solar arrays had a negative net present value. However, we recommend that the Patterson School Foundation construct a small 1 kilowatt wind turbine and a small 15 kilowatt solar array on their property. These renewable energy plays will be used to increase the overall sustainability of the Patterson School. Additionally, they can be leveraged to bring in revenue streams through the introduction of sustainability classes.

Since the sustainable energy projects have negative net present values, other revenue streams needed to be pursued. We examined the possibility of introducing small-scale educational classes at the Patterson School. We chose to examine small-scale educational courses for two reasons. First, the Patterson School has the strong educational background to facilitate this type of project. Additionally, our research suggests that there is a strong demand for small scale courses focusing on sustainability. Our team chose to investigate the logistics of offering classes on permaculture and renewable energy. Permaculture was chosen because the Patterson School has expressed interest in this topic, and because their abundant land resources are ideal for demonstration purposes. Renewable energy was chosen as a course topic because we see a strong demand for these types of courses, and because it can leverage the recommended renewable energy installations.

To determine the overall economic benefit of the recommended projects a financial model was created. This model considered all expected costs and revenue streams incurred by the renewable energy projects and small-scale educational classes. The model assumes the fixed costs of the projects would be incurred at year zero. Classes are assumed to begin with an enrollment of 10 students per class and grow at a rate of 20 percent each year, until a predetermined class capacity is reached. The variable cost of the course is calculated to grow alongside the class as capacity increases. Under these assumptions the simple payback period of the portfolio was found to be three years when no discount rate was applied. When discounted at a rate of six percent the simple payback period increased to three and half years. After this point in time revenues will grow until the eighth year. After the eighth year, the revenue stream is expected to be steady and generate 52,038 dollars each year.

Due to the strong economic performance of the portfolio we recommend that the Patterson School install small-scale renewable energy systems on their property. Additionally, we recommend that the Patterson School introduce small-scale educational courses, starting with classes on permaculture and renewable energy. Our analysis suggests that if the Patterson School Foundation follows these recommendations they will see an increase in the overall sustainability of their organization. Additionally, the portfolio of projects will pay for itself in under four years. This report will examine each project in detail. The proposed plan for the Patterson School takes into consideration the strengths, weaknesses, opportunities, and risks associated with each recommendation.

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# 1. Introduction

The Patterson School Foundation is located in Happy Valley, North Carolina and is bestowed with 1,400 acres of land. The property was originally a plantation owned by Samuel Legerwood Patterson (TPSF, 2015a). The land was later given to the Episcopal Church to be used as an agricultural school (TPSF, 2015a). Afterward, the property operated as a teaching school, working farm, and dairy for some time. The Patterson School ceased to operate as an educational institute in 2009 due to economic constraints.

Today the Patterson School consists of former academic buildings, residential homes, and agricultural buildings. The academic buildings on the property include two dormitories, a school heath center, a library, several buildings that served as classrooms, a cafeteria, and a church. Several of these buildings are closed and non-operational.

Of the existing buildings only a small portion are being utilized. The foundation uses these buildings for two purposes. The Patterson School leases buildings to Caldwell County Schools for science education. In addition to educational leasing, the Patterson School uses the remaining operational buildings for administrative purposes.

## The Patterson School Foundation and Nicholas School Partnership

The Patterson School Foundation reached out to the Nicholas School to become a Masters Project client. The Foundation wished to consult with Nicholas School students in order to develop plans for their property. Specifically, they were interested in strategies that move them toward greater environmental sustainability while still generating revenue. Our team believes that the Patterson School can rebrand themselves as a local leader in sustainability and become a sustainability destination. However, to accomplish this goal the Patterson School must first bolster their sustainability credentials. This process will take time to implement, likely several years, and will encompass multiple projects.

The major problem facing the Patterson School is that they lack the necessary funds to put toward sustainability projects. This reality requires that our analysis, and recommendations, focus on the short term. Our recommendations must not only work to increase the overall sustainability of the Patterson School, but must also enable them to generate revenue for reinvestment purposes.

### Development Strategies:

After careful consideration our team has decided to recommend the transformation of the Patterson School Foundation into a sustainable site for educational and recreational purposes. We envision the Patterson School providing courses on renewable energy, organic farming, and other sustainability topics. Our team believes that we can help the Patterson School move forward with this vision by providing the following: an evaluation of natural resources that can be used for renewable energy development, an evaluation of the economic and environmental benefits that can be expected from renewable energy projects, an evaluation of the markets for courses on sustainability, the expected economic benefits that will arise from such courses, and a foundation for future curriculum development.

A major portion of the Sustainable Patterson strategy is to start the Patterson School Foundation down a path of sustainable development projects. These projects will serve the dual purpose of increasing the overall sustainability of the Patterson School while also acting as revenue generators.

## 2. Materials and Methods

The team investigated several strategies that aimed to increase the overall sustainability of the Patterson School. The projects blended economic and sustainable development initiatives with the end goal of attracting patrons to the Patterson School. Projects of interest included renewable energy development and establishing environmentally focused camps, workshops, and seminars.

Each project entailed an economic analysis and a sustainability analysis. The economic analysis examined how the projects can develop the Patterson School financially. The sustainability analysis determined, in both quantitative and qualitative manners, how each proposed project could increase the environmental sustainability of the Patterson School.

# 3. Results and Observations

## Renewable Energy Analysis

### Natural Resource Evaluation and Potential for Renewable Energy

The land owned by the Patterson School Foundation can be broadly thought of as two distinct areas. First, there is the land located on mountain ridges. This land is predominately forested. The second area is the land found in the mountain valleys. This land has been predominately cleared of trees. Soil in the valley is quite fertile. The Patterson School leases several acres of this land to local farmers for agricultural production. The Patterson School itself does not actively farm the land. As a result, most of the land is planted with cover crops to maintain the soil.

The Patterson School Foundation stated that they are interested in developing renewable energy on the property. After conducting a walking tour of the property the team agreed that the unused acreage may hold potential for large-scale renewable energy projects. Solar, wind, and hydroelectric systems were investigated immediately. Our initial analyses of wind, solar, and hydroelectric power are discussed below.

### Wind: Initial Analysis

The ridgeline property owned by the Patterson School is of interest for wind energy development. Typically, mountain ridges experience high wind speeds due to the upslope flow of air parcels. These high wind speeds are naturally attractive for the development of wind turbines. However, North Carolina has outlawed the construction of wind turbines taller than 100 feet on mountain ridges (NCGA, 1983). This means that only small-scale wind turbines can be installed on mountain ridges; greatly limiting the economic opportunities of wind power on the Patterson School property. While large-scale wind turbines cannot be constructed on the ridges of the Patterson School, we believed the climatic conditions in the valley could prove favorable for wind power development. Therefore, a thorough analysis of wind power at the Patterson School was conducted.

## Solar: Initial Analysis

Our team investigated the feasibility of solar power development in the valley. Estimates from the National Renewable Energy Laboratory (NREL) show that solar insolation near the Patterson School is approximately 5 kilo-watt hours per square meter each day (National Renewable Energy Laboratory [NREL], 2015a) . Our team theorized that the Foundation could dedicate several acres of land to a solar photovoltaic (PV) farm. This option is attractive because there are multiple companies that would install photovoltaics on the Patterson School property under a leasing agreement. In such an agreement, the Patterson School would lease the land to a company under a long term lease agreement. During this time, the leasing company would construct solar energy systems and sell power to the grid while making rent payments to the Patterson School. This is a long term, no-cost solution that would meet the Patterson School's development criteria.

The Patterson School had previously been approached by Strata Solar, who was interested in leasing land that was already cleared in the valley. This proposal was rejected because the Patterson School was not willing to part with premium agricultural land for such a long time period. The Patterson School wants to preserve their agricultural land and heritage if possible. Therefore, our group chose to not pursue large-scale photovoltaic installations as a development strategy.

While large-scale development of solar power is not ideal for the Patterson School, there could still be benefits associated with installing smaller rooftop solar panels on their property. Rooftop solar is an attractive option for the Patterson School because these systems can be built on top of their existing infrastructure. This would allow them to produce renewable energy without sacrificing agricultural land. The power generated from these systems could offset large amounts of electricity purchases for the Patterson School and offer other less tangible benefits. For example, the installation of solar panels could significantly lower the carbon footprint of the Patterson School Foundation. A detailed analysis of roof-top solar will be discussed in a later section of this report.

## Hydroelectric Power: Initial Analysis

Another renewable energy strategy involves redeveloping the Patterson School's dam. Buffalo Creek, which runs through the property, had previously been dammed by the Foundation. According to Jim Hogan, the CEO and President of the Patterson School, the dam was originally used to provide electricity to the school when it was smaller. However, once the electric utility company came to the valley the penstock of the dam was destroyed, and one of the two turbines was sold. Our team explored the possibility of restoring the dam to a small-scale hydroelectric plant.

Schematics suggest that the original dam turbines were rated at 50 horsepower. This amount of power translates into approximately 37.2 kilowatts. Thus, if the dam were operating 90 percent of the time, which is fairly typical for a hydroelectric plant, it could produce close to 300 megawatt hours (MWh) of electricity in a year. This has a market value of roughly 18,450 dollars at a rate of 6.15 cents per kilowatt hour (kWh).

Further investigation revealed that the restoration of the dam was an inappropriate project for the Patterson School. This conclusion was reached due to the large costs and potential legal challenges that the Patterson School would likely run into. An initial estimate suggests that the cost to repair the penstock and install new turbines would cost roughly 250,000 dollars. This would mean that the hydro plant restoration project would have a simple payback period, or the number of years it would take for the project to break even, of nearly 13 years. This is a somewhat reasonable payback period, and may prove to be a promising long term strategy. However, the cost to the Patterson School simply cannot be sustained at this time.

Additionally, the river currently runs freely, if slightly impeded, because of the dam's damaged penstock. Getting permission to re-dam this river from the government could prove to be challenging. At a minimum, the Patterson School would have to draft a comprehensive development plan and submit it to the Federal Energy Regulatory Commission (FERC) (Anderson, 2015). This plan would need to outline the project and show compliance with the Clean Water Act (CWA) (Anderson, 2015). Due to the small size of the plant, the project could qualify for several exemptions. Most notably, the project could qualify as a "Qualifying Conduit

Hydropower Facility”, a “Conduit Exemption”, or a “10-MW Exemption” (Federal Energy Regulatory Commission [FERC], 2013). The most promising of these is the exemption for a “Qualifying Conduit Hydropower Facility”. Since the hydro plant would have an installed capacity of less than 5 megawatts, the dam would not have to be licensed by FERC as a qualifying facility (FERC, 2013). Nevertheless, the Patterson School would still need to submit a “Notice of Intent to Construct a Qualifying Conduit Hydropower Facility” to FERC (FERC, 2013). A plant of this size does not require an Environmental Assessment (EA) or an Environmental Impact Statement (EIS) (FERC, 2013). However, the FERC can require that an EA or an EIS be submitted at a later date (FERC, 2013).  Furthermore, the project may require collaboration with the US Army Corps of Engineers (Western North Carolina Renewable Energy Initiative [WNCREI], 2007).

Additionally, there are state level laws that must be considered. The Division of Energy, Mineral and Land Resources (DEMLR), a division of the North Carolina Department of Environment and Natural Resources (NCDENR), oversees dam construction and restoration projects within the state (North Carolina Department of Environment and Natural Resources [NCDENR], 2015). Before restoration of the dam can begin, the Foundation must file paperwork to determine if the dam falls under the jurisdiction of the Dam Safety Law of 1967 (NCDENR, 2013). To do this, the Patterson School must fill out the “’Form to determine if a dam is governed by the Dam Safety Law of 1967’” and the “‘Dam Hazard Classification Data’” form (NCDENR, 2013). Depending on the size of the dam and its capacity, the dam may or may not fall under the jurisdiction of the Dam Safety Law of 1967. If the dam is not subject to this law then a permit is not required for its modifications or repairs (NCDENR, 2013). If the dam is subject to the Dam Safety Law of 1967, the process becomes much more complex. To repair the dam under the jurisdiction of this law would require extensive planning and an analysis by a professional engineer (NCDENR 2013). Additionally, multiple reports and investigations of the dam must be conducted (NCDENR, 2013). Once all of the required paperwork has been filed the project would be reviewed by the State, and if approved by the Director of the Division of Land Resources then the repair process could begin (NCDENR2013).

Our research suggests that due to the small size of the dam on the Patterson School property and the fact that it is on a non-navigable stream, jurisdictional oversight would be minimal if required at all. Nevertheless, the paperwork must be submitted to the proper authorities. There is no guaranteed timeline by which the paperwork would be returned. Therefore, it is unknown how quickly the Patterson School could begin reconstruction of the dam. Additionally, the cost to reconstruct the dam is prohibitively high. For these reasons, our team recommends that the Patterson School not pursue dam restoration until they are on more stable economic grounds and can afford the many costs and road-blocks that may be associated with this project.

### Potential for Wind Power at the Patterson School Foundation

To determine whether wind power is appropriate for the Patterson School, a comprehensive model was created. The model was used to evaluate wind resources and potential revenues generated from power production. The first step in the process was data collection. Unfortunately, no wind data was directly available from the Patterson School. Instead, data was collected from the National Oceanic and Atmospheric Administration's (NOAA) Quality Controlled Local Climatological Data program (QCLCD) (National Oceanic and Atmospheric Administration [NOAA], 2015). This program offers detailed climatological data for local areas in 1,600 locations across the country. Additionally, the program offers data recorded in 60 minute intervals.

The closest NOAA QCLCD monitoring stations to the Patterson School are the Hickory Regional Airport and a weather station in Boone. The distances of the Boone Weather Station and the Hickory Regional Airport to the Patterson School are 16.5 and 20 miles respectively. Both collect hourly climatological data. However, elevation differences between the sites are significant, and elevation can have a large impact on wind speeds. The Patterson School has an elevation of approximately 1,168 feet above sea level, Boone has an elevation of 3,333 feet above sea level, and Hickory has an elevation of 1,143 feet above sea level. The difference in elevation between Hickory and the Paterson School is approximately 25 feet. As the elevation of the Hickory location is much closer to that of the Patterson School, the wind data from the

Hickory Regional Airport was chosen to serve as a proxy for the Patterson School in the model created for this assessment.

Weather data between the years 2011 and 2013 was collected and imported into Excel. In total there were 34,980 unique wind speed observations. This is equivalent to nearly one observation every 45 minutes over the three year period. To begin, a basic statistical analysis was conducted on this data. The average mathematical mean of wind speeds at the observation site was 3.89 miles per hour (MPH). The standard deviation was 4.07 MPH. The most observed wind speed was zero MPH.

A histogram of the data was then generated to determine wind speed distribution. Interestingly, the data was distributed in a nearly exponential fashion. **Figure 1**, found in Appendix A1, shows the distribution of the data. The discovery that the data was distributed exponentially was surprising, as most wind speeds follow a distribution that is similar to a positively skewed bell curve. This observation means that the model will have to be carefully constructed to account for the unusual distribution.

Close examination reveals that the data is not truly exponentially distributed. However, the model will treat the data as though it were, as this will result in the most accurate predictions. The key parameter that determines the shape of an exponential distribution is represented by the Greek letter lambda. In this case lambda is simply one divided by the average wind speed. Using this information, a probability density function (PDF) and a cumulative distribution function (CDF) were created. A graphical representation of the PDF is shown in **Figure 2**, found in Appendix A1 of this report. This graphic shows the probability of any one wind speed occurring in the model. The CDF was used to make the model itself and was paired with a random number generator. The random number generator created random values between zero and one. These numbers were used to simulate a hypothetical wind speed observation in the model by representing a point along the cumulative distribution function. Knowing this, the value of the decimal could then be looked up with a corresponding wind speed. This process was then repeated 34,980 times to simulate three years of wind speed data at the Patterson School.

To verify whether the resulting simulation was accurate, the three years of modeled wind data was plotted against the observed data. If the data from the model closely follows the observed data then we can be confident in the predicting power of the model. **Figure 3**, found in Appendix A1, shows the results of plotting the modeled wind speeds against the observed wind speeds. We can see that the overall shape of the model is similar to the observed data. The differences between the modeled and the observed data seen in the lower wind speeds are due to the fact that the observed data is not truly exponentially distributed. This means that the model will slightly under predict the occurrence of wind speeds between three and eight miles per hour.

Once the ability of the model to predict wind speeds was deemed accurate, the model then had to account for site differences between the Patterson School and Hickory Regional Airport. First, the wind shear at the Hickory Regional Airport had to be determined. This was done by speaking with NOAA employees in Asheville, North Carolina. The employees revealed that the recording device at the Hickory Regional Airport is located in a large clear patch of land at a height of 26 feet above the ground. Based on this description we determined that the alpha value to be used in the wind shear models should be 0.34 (Kaltschmitt et. al, 2007).

Next, we wanted to determine the best case scenario for wind production at the Patterson School. To accomplish this, a large turbine with a very low cut in speed was selected as an initial investigation point. This combination of features was chosen because large turbines tend to have a high hub height, meaning that they are situated high in the air. This is important for a wind turbine because wind speeds tend to increase with height, which translates to more power output. Additionally, large turbines also possess a large turbine rotor radius, which again results in more power output. Furthermore, the low cut-in speed ensures that the turbine is producing power as often as possible. This situation would essentially model the maximum power production, and thus the maximum revenue, that could be generated through a single wind turbine at the Patterson School. The result of this model showed that the overall wind resources at the Patterson School are less than ideal. However, our team believes that the wind turbine can play a strategic role for the Patterson School, so further modeling with smaller and more affordable turbines was pursued.

Several wind turbines currently on the market were incorporated into the model. Due to the limited wind resources at the Patterson School Foundation, turbines with power ratings between 1 kW and 10 kW were selected. While larger turbines would ultimately generate more power and revenue, their higher costs would be problematic for the Patterson School and their payback period would be unacceptable. Additionally, larger turbines would come with zoning issues and other legal concerns that could be costly to address.

The next step was to incorporate installation costs into the model. Installation costs can be difficult to determine. An important factor to consider is the location of the installation site. At the Patterson School, there is abundant land that is clear of obstruction. These locations tend to be in the valley where wind resources are poor. An ideal location would be higher on the mountain ridge, however as mentioned earlier, laws prevent the development of wind turbines directly on the ridge. Additionally, if a turbine were to be developed on the ridge it would require clearing land and potentially building an access road. This would greatly increase the installation costs of the turbine. There is little evidence to suggest that building on the ridge would increase revenues enough to justify the increased installation costs. Building the turbine closer to the campus itself would also allow better access to the turbine for educational purposes. Installation costs of the turbine were determined using figures from the US Department of Energy (DOE). In a 2013 study the DOE found that, on average, the cost to install a new wind turbine was 1,630 dollars per kilo-watt (Department of Energy [DOE], 2013). This is the number used to calculate the installation costs in the model.

The initial analysis of wind speeds at Patterson revealed that the property had relatively poor wind resources. Therefore, a small but efficient wind turbine was modeled for this report. The turbine used in the model is the BWC XL.1/MDC made by Bergey Windpower Company (Bergey Windpower Company, 2013). This turbine has a low cut in speed of 2.5 meters per second (or 5.59 miles per hour) and has a rated power output of 1 kilo-watt. Additionally, the model assumed a hub height of 10 meters above the ground. This would represent a height that could be achieved if the turbine was installed on top of a roof at the Patterson School. This wind turbine has an estimated total installed cost of 6,225 dollars.

Under these assumptions the model was run to simulate wind power production over a 20 year period. At the end of this time period, the wind turbine would have generated an estimated 14,025 kWh of electricity. Assuming that power costs 6.15 cents per kilo-watt hour, this means that the turbine would have saved roughly 912 dollars over the modeled time period. This project has a simple payback period of 136.5 years. At a discount rate of six percent this project has a net present value of -5,400 dollars over the modeled lifetime of the wind turbine. From a purely economic perspective, this is not a good investment opportunity. However, the wind turbine has other benefits in which the Patterson School may be interested.

There are opportunities to increase the economic performance of wind turbines at the Patterson School. An especially promising option is for the Patterson School to partner with NC GreenPower (NCGP). NC GreenPower is a non-profit that helps fund small-scale renewable energy projects in the state. They provide green power production incentives for wind and solar systems. For wind, NC GreenPower provides an incentive of nine cents per kilowatt-hour produced (NC GreenPower [NCGP], 2015). Assuming a successful partnership with NC GreenPower, the revenue from the wind turbine jumps to an average of 63.12 dollars per year. In this situation the payback period would drop to 98.62 years.

Additionally, there is the possibility that the Patterson School could get an additional 4 cents per kilowatt-hour through their electric utility provider (DOE, 2014a)**.** This means that the Patterson School could conceivably make 13 cents per kilowatt-hour of electricity produced from a wind turbine. In this situation, the 1 kW rated wind turbine would produce about 91 dollars a year in revenue. This would drop the simple payback period to roughly 69 years. This is the best case scenario for the Patterson School for wind power production on their property. Our research suggests that there are no other wind power production incentives in North Carolina. However, some of the construction costs may be covered by grants, which could lower the initial investment cost and further increase the economic performance of wind turbines.

Additionally, there will be some operation and maintenance costs associated with a wind turbine. Typically, operation and maintenance costs for a wind turbine are between 1.5 and 2 percent of the price of the wind turbine (Wind Measurement International [WMI], 2015). However, this figure is for wind turbines that are expected to operate 66 percent of the time (WMI, 2015). Our analysis found that this wind turbine would be operational less than 50 percent of the time throughout any given year. Therefore, the wear and tear on the turbine would be less than those with operation and maintenance costs between 1.5 and 2 percent. For this reason we estimate that the operation and maintenance costs for a wind turbine at the Patterson School is likely to be closer to 1 percent. Under this assumption, the modeled turbine will have a yearly operation and maintenance cost of 45.95 dollars per year. Depending on the rate at which Patterson sells the electricity produced from the turbine, the operation and maintenance costs could erode a significant proportion of generated revenues. If Patterson were using this electricity at 6.15 cents per kWh, the lowest possible rate, then the turbine would generate enough revenue each year to cover its operation and maintenance costs. However, if the Patterson School managed to form a partnership with NC GreenPower and the electric utility, then the revenues from the wind turbine could cover the yearly operation and maintenance costs while leaving an estimated 45 dollars in profit each year.

We also investigated the use of turbines rated up to 10 kilo-watts in the model. It was found that these larger turbines did increase yearly revenue. However, revenue did not increase by an amount significant enough to overcome the increased cost of the larger turbines. As a result, larger turbines have increasingly longer payback periods. For this reason, we recommend that the Patterson School not pursue a wind turbine with a power rating larger than 1 kilo-watt.

It is worth noting that our model is a conservative one. As mentioned previously, the model under-predicts the occurrence of wind speeds between three and eight miles per hour. This is not a large concern for wind speeds under six miles per hour. This is because these speeds are below the cut in speed of the turbine, and would therefore not produce power. We can expect there to be slightly more occurrences of winds speeds between six and eight miles per hour than were predicted by the model. This means that the wind turbine should produce slightly more power than our model suggests. However, this will not have a significant impact on power generation.

## Potential for Solar at the Patterson School Foundation

In order to explore whether solar energy is applicable for the Patterson School a solar model was constructed using the PVWatts calculator to analyze the solar resources and potential revenues and costs of power generation (NREL 2015b). Because solar power is a completely new project to the Patterson School no historical solar insolation data could be collected from the school. Therefore, the nearest TMY3 (The Third Typical Meteorological Year Collection) location was selected for the calculation. This location was Hickory Regional Airport, with a latitude of 35.733, a longitude of 81.383, and an elevation of 1,143 feet. The TYM3 estimate is quite robust, and contains a mix of measured and modeled solar resource data for 1,020 sites from the years 1991 to 2005 (Wilcox, et. al, 2008). This location is 20 miles from the Patterson School.

Solar energy generation requires several conditions, including abundant sunshine and adequate space. Three criteria regarding building selection were proposed as follows. First, the long side of the building should face south. Second, on sloped roof buildings, solar panels should be installed on the south facing slope. And third, there should be little vegetation that could block incoming solar radiation. There should be little, if any, competing infrastructure on the rooftops. Roofs should have abundant space for panel installation. All three requirements mentioned above should be followed to ensure that a sufficient number of solar panels can be installed, and that adequate solar insolation can be received by the panels.

To determine which buildings at the Patterson School met our identified criteria we utilized a combination of on-site field research and Google Earth (**Figure 4** in Appendix A1). Six buildings were selected as having potential for solar panel installation. Using Google Earth and a detailed map provided by the Patterson School, we identified the following six buildings as the most suitable ones for solar installation: Palmyra/Administration Building, Wiese Residence Hall, Hickory Dining Hall, Staff Housing, Chester Classroom Building, and Stoney Classroom Building. As calculated from the blueprint information, the roof space is 458.85 $m^2$, 497.18 $m^2$, 342.72 $m^2$, 200.1 $m^2$, 212.28 $m^2$, and 332.34 $m^2$ for the six buildings respectively.

To calculate the solar energy output of the six buildings at the Patterson School several items of information are needed, including: DC system size, module type, array type, and tilt. DC system size is the direct current (DC) power rating of the photovoltaic (PV) array in kilowatts (kW) at standard test conditions (STC). The DC system size (kW) is calculated through the formulation below:

$$DC\ system\ Size\ (kW) = Array\ Area\ (m^2) \times 1kW/m^2 \times Module\ Efficiency\ (\%)$$

Typically, the module efficiency is related to the module type. The standard for crystalline silicon has an approximate efficiency of 15 percent (NREL, 2015b). In addition, because we proposed to develop roof-top solar panels for the Patterson School, the array type should be a fixed roof mount. Tilt of the panels also affects the solar energy generation. For the Patterson School we set the tilt at 20 degrees. Moreover, because spaces are needed between solar panels for ancillary infrastructures, we determined the area to include in our calculations to be 50 percent of the total roof area. Putting all parameters into the model, we arrived at the results shown in **Table 1** (Appendix A2).

The potential cost of this project is the total photovoltaic system installation cost including module, inverter, other hardware costs, labor, and other non-hardware costs. According to Photovoltaic System Pricing Trends, the default cost is 3.7 dollars per direct current watt (Feldman, et. Al, 2013). The calculation should be written as follows:

$$Total\ cost\ (\$) = default\ value\ (\$/W) \times DC\ system\ Size(kW) \times 1000W/kW$$

Incorporating the results of the solar model in this calculation, the total cost for solar panels on these six buildings should be approximately 567,062.93 dollars.

The potential revenue of the solar panels comes from avoided electricity costs. The Patterson School purchases electricity from Blue Ridge Electric, which provides electricity at 6.15 cents per kilo-watt hour. The savings achieved through solar panels is calculated according to the formula below.

$$Total\ Revenue\ (\$) = electricity\ price\ (\$/kWh) \times electricity\ generation(kWh)$$

According to this calculation, the system would generate an estimated 12,577.80 dollars per year.

Without considering a discount rate, the payback period will be 46 years. However, according to the report by Oxera, the discount rate for solar PV is between six and nine percent (Oxera, 2011). Therefore, the payback period will be more than one hundred years when a discount rate is applied. The total profits of the solar panels, including a discount rate of six percent, are -344,855 dollars. As a result, the Patterson School may not be able to construct all the solar panels on the identified buildings. Instead, the Patterson School should choose a few buildings for solar panel installation. Costs, potential revenues, and stable net profits (with a discount rate of six percent) of the identified buildings are provided in **Table 2** (Appendix A2). As is demonstrated in Table 2, the solar energy system for Staff Housing requires the least investment among the buildings, indicating that this location may be the optimal choice for the Patterson School.

### Legal and Political Considerations of Wind and Solar

Certain regulatory policies exist in North Carolina for wind turbine installation. In Wind Energy Permitting Standards, it is stated that any wind turbine erected within half a mile of another turbine must get a permit from the Department of Environment and Natural Resources (DENR) before construction if their capacity is larger than one megawatt (MW)(NCGA, 2013). For turbine construction, the Model Wind Ordinance proposed by North Carolina Wind Working Group indicates that a single wind turbine with power equal to or less than 20 kilowatts (kW) should be classified as "small". The ordinance also regulates setbacks corresponding to small scale wind turbines to ensure public safety and mitigate noise impacts as well as shadow flicker (North Carolina Wind Working Group, 2008).

Additionally, North Carolina provides many incentives to build wind turbines for power generation. Net metering is available to customers who own and operate wind energy systems for electricity generation, with a capacity limit for non-residential systems of 100 kW (DOE, 2009). The NC GreenPower Production program encourages the use of renewable energy in North Carolina. Owners of small wind-energy systems can get nine cents per kWh from NC

GreenPower and approximately four cents per kWh from their electric utility, totaling thirteen cents per kWh in production payments (DOE, 2014a).

Considerable financial incentives, rules, programs, and initiatives related to solar energy exist in North Carolina. Property-Assessed Clean Energy (PACE) financing allows property owners to borrow money for energy improvements. Legislation (S.B. 97) was enacted in North Carolina in 2009 to authorize counties and cities to assess and explore whether to finance the installation of “distributed generation renewable energy sources or energy efficiency improvements that are permanently fixed to residential, commercial, industrial or other real property” (DOE, 2014c). In addition, NC GreenPower also offers production payments for grid-tied electricity generated by solar energy systems. Owners of small solar energy systems (5kW or less) can currently apply to participate in the program anytime by filling out an online application on the NC GreenPower website (DOE, 2014a). The Solar Solutions Initiative (SSI) offers additional financial incentives for Solar PV systems participating in the Renewable Standard Offer program. Additionally, net metering is available to all customers who own and operate systems that use solar energy for electricity generation. Customers can net meter under any available rate schedule (DOE, 2009). Renewable Energy and Energy Efficiency Portfolio Standards are also implemented in North Carolina (DOE, 2015).

### Sustainability Assessment of Renewable Energy Development

The Patterson School purchases their electricity from Blue Ridge Electric (BRE), who in turn purchases electricity from Duke Energy of the Carolinas. Based on this information we can determine how the electricity was likely generated using the Patterson School’s area code. **Table 3** (Appendix A2) shows the likely generation profile of the electricity that the Patterson School receives from Blue Ridge Electric (Blue Ridge Electric, 2015)(Environmental Protection Agency [EPA], 2015a).

Based on this information we can determine that for every kWh of electricity purchased by the Patterson School, roughly 1.074 pounds of carbon dioxide are released into the atmosphere. In 2013 the Patterson School purchased 426,992 kWh worth of electricity. This amount of electricity consumption translates into 458,589 pounds of carbon dioxide released into the atmosphere in 2013 (EPA, 2015b). Assuming that 2013 is representative of normal electricity purchases at the Patterson School, this number can be used for comparison purposes.

Under these assumptions the modeled wind turbine only offers modest carbon savings. The modeled wind turbine will save an estimated 7.5 tons of carbon dioxide from being released into the atmosphere over its lifetime. This equates to a savings of roughly 0.38 tons or 760 pounds of carbon dioxide per year. For the Patterson School this represents a 0.18 percent reduction in their carbon footprint.

Development of rooftop solar at the Patterson School offers significantly more carbon savings. The modeled solar panels offer a savings of 219,651 pounds, or nearly 110 tons of carbon dioxide per year (EPA, 2015c). This solar energy system would therefore reduce the yearly carbon emission of the Patterson School by 47.9 percent. As a carbon mitigation tool, rooftop solar is a very attractive option for the Patterson School. **Table 4** (Appendix A2) shows how much carbon dioxide each solar system averts by installation building.

## 4. Small Scale Environmental Education Programs as a Development Strategy

In this analysis, small scale or small format education refers to educational programs that last only a few days at a time. Typically, these types of classes are taught over a weekend, but they could be held during the work week as well. Furthermore, small format classes can be continued over a series of meetings. For example, a course that is more in depth may be held over the course of several weekends. The opportunities, strengths, and weaknesses of holding these types of educational classes at the Patterson School are discussed in depth in this analysis.

Small scale education is perhaps the best option for the Patterson School to realize long term economic recovery. This is because small scale education, such as overnight workshops or seminars, can effectively utilize existing infrastructure at the Patterson School. Patterson has existing dormitories and a cafeteria. Therefore, space and general living requirements for holding these educational events are already met. To start small format education all that is required is to develop a course curriculum and find the correct individuals to lead each course. The short term format is beneficial here as well. Short format classes allow whomever is leading the class, whether a Patterson School official or a visiting instructor, to commit to teaching the course in their spare time. This flexibility will therefore allow a wide variety of classes to be held and at high frequencies.

We recommend that the Patterson School start with two kinds of sustainability courses: the Permaculture Design Course (PDC) and the Renewable Energy Course (REC). These courses will serve as major anchor courses that will attract people to the property. A variety of sustainability courses can be offered at the Patterson School in the future. Future courses could be set up to build off of these recommend starting courses. However, there is strong potential for additional courses to be taught on other subject matter. A variety of classes that could be held at the Patterson School will be discussed in several case studies.

## The Permaculture Design Course (PDC)

### Introduction of Permaculture and the PDC

Permaculture design aims to create an integrated lifestyle based on the unique resources and landscape of an area to realize the goal of sustainable development.  The idea of permaculture was first raised in 1978 as the combination of the word “permanent” and “agriculture”. The culture became popular in the 1980s, when an activist began to teach permaculture worldwide. In the 1990s the number of permaculture courses climbed rapidly. By 2002, over 100,000 people had been trained in permaculture design (Bane, 2002). The Permaculture Institute was founded by Bill Mollison in 1996, offering one of the most influential certification courses: the Permaculture Design Certificate (PDC). The difference between permaculture and sustainable living is that permaculture incorporates landscape design and agriculture. More specifically, it emphasized an integrated lifestyle based on one’s unique resources.

According to the Patterson School’s website, the Foundation has been working with the Permaculture committee in redesigning the landscape of its 1,400 acres according to the permaculture principal. With the development of our sustainable energy projects (wind and rooftop solar), the Patterson School can become an excellent example of sustainable agriculture. We believe the Patterson School could be an ideal institution to offer the PDC course due to its rich experience in education and ample farmland for students to learn and practice permaculture ideals. Any institute that opens this course must be authorized by the Permaculture Institute.

The PDC has been broadly recognized as incorporating the most important ideas and methodologies of permaculture design. The course has been developed over many years and is especially respected because of its rigorous standard of completion and the quality of the curriculum. Individuals must complete all required courses and a final design project in order to obtain this certificate.

The most important value of the PDC is that it gives holders the credentials to make statements about “permaculture” in their marketing materials. As permaculture has become a widely accepted idea, statements about permaculture are valued by employers, clients and customers. Furthermore, the PDC is recognized as college credit by a number of universities and serves as a prerequisite for some advanced agriculture courses. Thus, the PDC can prepare holders for further study in this area. Last but not least, PDC can provide a systematic way to reorganize one’s natural resources in an efficient manner.

## Market Analysis

Analysis of this market is based on online research. The analysis focuses on the segment market of North Carolina, South Carolina and Virginia.

The market size for PDC courses is growing according to two observations. First, the number of courses offered has been growing gradually through the years. For example, this year two NGOs (*Gather and Grow*, *Surplus Permanent Design*) in South Carolina are offering the first PDC courses in their region (South Carolina Permaculture Design Course,2015). Second, the PDC classes of Spring 2015 are all full, which shows a solid demand of this course.

The PDC courses are normally offered in four ways with distinctive price ranges. An online course option is typically offered for free; the weekend course, without boarding, costs between 895 and 1,200 dollars; the all-inclusive boarding course costs 2,000 dollars; and the touring course costs 3,000 dollars (Beginning Farmers, 2015).

The most popular online course is offered by North Carolina State University with 29 lectures and materials covering gardening, soil and irrigation. Another popular online course is offered by the Regenerative Leadership Institute, with free online material accessed by a simple registration of one's name and email address. The advantage of online courses is that they are free, convenient, and require no strict time investment. However, although online courses cover the most important aspects of the permaculture design course, they are not able to issue certification.

The weekend course without accommodation is the most economical way to obtain this certificate. The course will usually be offered over four consecutive weekends, according to the guidelines of the PDC syllabus. The weekday courses are the most expensive and intensive way to learn permaculture design. The course is typically offered at either a domestic farm or over a fieldtrip to another country (Canada, Mexico, or Puerto Rico). The fee of weekday courses includes the travel expenses for 12 to 15 days.

The following groups are expected to be Patterson's potential students:

- Landowners who wish to better utilize their land and natural resources.
- Land planners and land managers who need the design skills to better integrate sustainability into a land management plan.
- Land users (farmers and land renters) who are seeking better yields with less input.
- Architects and building professionals who want to innovate in a sustainable fashion according to permaculture principles.
- NGOs that need to utilize permaculture statements for advocacy needs.
- Entrepreneurs who want to make permaculture statements to promote sales, marketing campaigns, or branding.
- College students who are interested in earning credits toward a degree in agriculture.
- Environmental activists and agriculture enthusiasts.

Based on the market research, we believe the permaculture market in North Carolina is attractive. The Patterson School's competitive advantages in this market are:

- The land at the Patterson School is good for demonstration purposes. Additionally, the Patterson School has been working with the Permaculture committee to redesign their landscape.
- Rich experience in the education field.
- Possess the largest amount of land in the market for students to practice learned skills (1,400 acres).
- Small scale renewable energy systems on site for educational use.
- Existing facilities for boarding.

### Tentative Curriculum

A tentative curriculum was developed for the permaculture course at the Patterson School. The curriculum would have to be recognized by the Permaculture Design Institute as standardized coursework before enrolling students. According to the requirements of the Permaculture Design Institute, the entire certificate course should meet the following criteria (Permaculture Institute, 2015):

- The lead instructor should have a diploma in education and should have obtained the PDC diploma. A PDC diploma requires substantial practical experience, and excellence in professional permaculture practice. Co-teachers do not need to have the PDC diploma.
- The course should be at least 72 hours of direct teaching from the instructor.
- The course should cover all the subjects on the PDC syllabus offered by the Permaculture Institute.
- The course should include at least one design project.
- The course should end with a presentation of final design projects.

Both curriculums require a minimum of 72 hours of lecture study over 12 consecutive weekdays or weekends. The course curriculum is a tentative version designed by Nicholas School students in reference to the PDC offered by Urban Harvest, an important PDC institution in the United

States. Modifications in course content, course length, instructor, and schedule are expected in the future. Tentative curriculum design is shown in **Table 5** (Appendix A2).

## The Renewable Energy Course

Keeping with the educational mission of the Patterson School and the desire to keep a strong commitment to the environment, we also recommend that the Patterson School implement courses on renewable energy and sustainability. An introduction to the renewable energy course, its benefits, and a basic curriculum are outlined below.

### Introduction of the Renewable Energy Course

The goal of the Renewable Energy Course (REC) is to leverage any installed renewable power systems on the Patterson School's property. The recommended wind turbine and rooftop solar panels can be used to teach course participants about renewable energy and allow them to see the end results. However, there must be a structured curriculum, and it must be interesting enough to attract students to the Patterson School. Luckily, there are a variety of successful non-profits whose methods can be emulated.

There is a very successful non-profit in California called the Solar Living Institute (Solar Living Institute, 2015). They teach several levels of renewable energy courses. These courses have different target audiences ranging from complete beginner to those already in the solar industry. In a similar manner, the Solar Living Institute offers basic courses on setting up solar energy systems for off grid living. We believe that the Patterson School Foundation could offer similar classes.

As a starting point, the Patterson School would be best served by establishing an introductory course to renewable energy. We envision such a course as being similar to the Introduction to Photovoltaics course found at the Solar Living Institute. The Introduction to Photovoltaics course runs over a two day period and costs 325 dollars per participant. The class covers the basic concepts of solar energy, goes over the components of a photovoltaic panel, and discusses how to determine system size based on costs and local incentives.

## Economic Benefits of the REC

In addition to leveraging installed renewable power systems on the Patterson School property the REC can also aid in the cost recovery of said systems. Our analysis suggests that if the cash flows from the REC course were diverted to pay for the wind and solar installations that the payback period would drop significantly. Assuming a starting class size of 10 persons, costing 300 dollars per person, with no class growth, the wind turbine would be paid back in roughly two years. Under the same assumptions, the solar panels on Staff Housing would have a payback period of about 18 years. In a more optimistic scenario, with 40 enrolled students per year, the renewable energy course would recover the costs of the wind turbine in less than a year, and the costs of the solar panels would be recovered in less than five years. In the long run, supplemental renewable energy courses will act as a long term revenue generator.

## Curriculum Design

Designing an entire curriculum for the renewable energy course is beyond the scope of this analysis. However, we can suggest an outline of what a renewable energy course could look like at the Patterson School. The curriculum will need to be developed by either a Patterson School official, an outside educator, or a sustainability intern. The outline provided can be used as a launching point for the creation of future classes.

Utilizing an intern to create the renewable energy course offers the Patterson School several advantages. The intern can create the content of the course at little to no direct cost to the Patterson School. Furthermore, there are several schools in North Carolina offering programs in sustainability that touch on renewable energy. As a starting point, we would recommend that the Patterson School reach out to the Sustainable Development and Appropriate Technology programs at Appalachian State University, and the Nicholas School of the Environment at Duke University. Additionally, North Carolina State University offers several degree programs that focus on sustainability.

We recommend that the renewable energy course cover the topics outlined in **Table 6**, located in Appendix A2. Topics that should be covered include: the basics of electricity, an introduction to wind power, an introduction to solar power, the economics of renewable energy, and legal issues surrounding renewable energy development in North Carolina.

## Additional Small Format Education Case Studies:

Our team has selected a few organizations throughout North Carolina that offer small format educational courses in subject areas similar to those suggested in this report. We will briefly analyze each organization, the courses they offer, and why they are successful. In this way, the Patterson School can offer programs that are similar to those that have already attracted customers. Additionally, the Patterson School can identify potential classes that they would like to incorporate at a later date, and develop these classes in a way that will give them an advantage over their competitors.

We also envision these small format classes going in one of two directions. The classes could either be general or technical in nature. A general level class would attract a large customer base, but the information given in these classes would be more basic in nature, and as a result would command a smaller price point. Alternatively, a more technical class would require a more knowledgeable staff and have a very specific focus. The more technical classes could also offer certification for those students completing the course. This more technical and in-depth approach would result in smaller classes but command a higher price point. In the case studies below we will highlight examples of both technical and general classes for both permaculture and renewable energy. Note that all information on competitors was obtained from their respective websites.

## Technical Courses:

### Renewable Energy: NC Clean Energy Technology Center

The North Carolina Clean Energy Technology Center, formerly the NC Solar Center, is a public service center at North Carolina State University. They offer two key development services. The first is a diploma series in Renewable Energy Technologies and the second is a certificate in Renewable Energy Management (NC Clean Energy Technology Center [NCCETC], 2015).

The Renewable Energy Technologies Diploma Series is not a degree, but rather focuses on continuing education. The series consists of five workshops. Each workshop is 40 hours in length and has a different renewable energy focus. The Photovoltaics and Solar Thermal courses allow participants to take entry level exams for the North American Board of Energy Practitioners (NABCEP). Their Photovoltaic and Solar Thermal instructors are either Certified Master Instructors or are certified by the NABCEP (NCCETC, 2015b). The Diploma Series also offers instruction on geothermal energy, wind energy, and building analysis. The overall focus of the Diploma Series is job training. The cost of the Diploma Series can reach up to 4,096 dollars depending on the courses taken.

The Certificate in Renewable Energy Management is offered in the Diploma Series (NCCETC, 2015c). This certificate is most similar to the programs that the Patterson School would offer if the School decides to pursue a technical renewable energy course. The certificate's primary focus is on the fundamentals of solar power technology (NCCETC, 2015c). There is additional focus on policy at the federal, state, and local level. The course also covers incentives and regulations that impact the renewable energy landscape, and discusses the finances of renewable energy. If all of the course requirements are met, participants receive a certificate in Renewable Energy Management from North Carolina State University. The cost of this program is 1,998 dollars.

Technical Permaculture Classes:

We Are All Farmers (WAAF) is a non-profit organization found in Union Grove, North Carolina. The organization specializes in increasing "food and energy responsibility and resilience" (We Are All Farmers [WAAF], 2014). Most notably, they offer an in-depth permaculture design course and run a separate permaculture focused business known as Full Wheel Farmers.

The Permaculture Design Certificate course offered by WAAF focuses on developing hands-on experience for the student. Their courses are centered on the book <u>Permaculture: A Designers' Manual</u>, written by Bill Mollison (WAAF, 2014). The course teaches permaculture techniques for land management and animal stewardship (WAAF, 2014). The course is taught by designing a permaculture setup for a community in need, giving students a chance to do design work for real clients. At the end of the course the permaculture designs are presented and evaluated. If their work is acceptable the participants are then awarded the Permaculture Design Certificate (PDC).

These courses are taught in eight hour increments (9 AM to 5 PM) over the course of five weekends.  The course cost is 850 dollars. WAAF allows camping on sight, but offers no other option for accommodations. Included in the price are three meals and daily snacks. WAAF states that this weekend format is especially valuable because it allows time during the week to review concepts, engage in individual work, and incorporate feedback to further develop skills and insights (WAAF, 2014).  WAAF also stresses community as a strong part of their permaculture design course. In addition to being a central tenant of their curriculum, they state that there are many benefits to teaching the course with a focus on community. These benefits include: greater understanding of the curriculum, developing friendships, and in some instances developing business partners (WAAF, 2014).

## General Purpose Small Format Classes

General purpose classes are far less technical in nature. As such they can be taught in a much shorter time frame and the instructor pool is much larger. This is attractive because it can allow the organization to offer classes on a wide variety of topics, allowing for repeat students. A prime example of this format is the Pickards Mountain Eco Institute.

Pickards Mountain Eco Institute (PMEI) offers a similar vision to that of the Patterson School. Located near Chapel Hill, North Carolina, this organization promotes sustainable living. PMEI is run by community members and interns who oversee “organic gardens, sustainable livestock production, and renewable energy systems” (Pickards Mountain Eco Institute [PMEI], 2015a). They promote themselves by offering education for children in primary school. Additionally, they offer internships to college students, and workshops that are open to adults. It seems that the organization keeps costs low by having very little full time staff. Rather, they operate through the efforts of volunteers and interns. Additionally, PMEI advertises that the organization is “community supported” and accepts donations.

PMEI offers a wide variety of classes, workshops, and camps. Some of the topics available to PMEI patrons include permaculture, mycology, renewable energy, organic farming, composting, yoga, systems theory, wild edibles, and beekeeping (PMEI, 2015a). Classes tend to be held over the course of one day. Children's summer camps offer different themes and experiences each week in an attempt to attract a variety of visitors and bring repeat campers. Children's summer camps cost 200 dollars each week (PMEI, 2015b).

## Other Competitors

There are several other competitors that offer similar products and services of which the Patterson School should be aware. Below, several competitors in North Carolina and one competitor in Tennessee are identified. Each organization is accompanied by a description of the services that are similar to what the Patterson School could offer. See **Table 7** for a full list of competitors. Again, information about each competitor was obtained through their respective websites.

**North Carolina Wind Energy:** North Carolina Wind Energy (NCWE) at Appalachian State University is sponsored by the Department of Energy's National Renewable Energy Laboratory. Their purpose is to install small scale wind turbines for educational purposes at schools. Typically NCWE works with primary and secondary schools and encourages the incorporation of renewable power generation into the school's curriculum. Additionally, NCWE offers educational workshops and other training opportunities (North Carolina Wind Energy, 2015). NCWE could offer excellent partnering opportunities for the Patterson School.

**Spiral Ridge Permaculture:** Spiral Ridge Permaculture (SRP) is located in Tennessee. The focus of SRP is on permaculture design and regenerative farming. Additionally, they emphasize teaching skills that can be used by individuals in their backyard or homestead. They offer a Permaculture Design Course, a series that focuses on resilience for small gardens, soils classes, and other niche topics. The permaculture design course at SRP is a 72 hour course held over multiple consecutive weekends (Spiral Ridge Permaculture, 2015). At the end of the course participants will receive a certificate in permaculture design. The permaculture design course costs 1,650 dollars per individual (Spiral Ridge Permaculture, 2015). Spiral Ridge Permaculture is considered one of the primary competitors in this region because they offer a PDC program at a North Carolina farm (Trout Lily Farm).

**Wild Abundance:** Wild Abundance teaches many different skills that focus on living more in-tune with nature. They are located in Asheville, North Carolina. Wild Abundance offers courses in eco-homesteading, self-sufficiency, organic gardening, wild food and medicine, permaculture, living off-grid, survival adventures, and primitive skills (Wild Abundance, 2015). Additionally, Wild Abundance also offers a permaculture design certificate program.

**Living Systems Design:** Living Systems Design began offering their 16-day PDC program in 2014 at the Earthhaven Ecovillage in the Black Mountain area of North Carolina. The cost of the program ranges from 900 dollars to 1,200 dollars depending on the registration time slot (Living Systems Design, 2014). The PDC program includes visits to existing successful permaculture sites. They offer work-trade and scholarship opportunities for students to finance their tuition.

**The Permaculture School:** The Permaculture School is an institution that focuses on the idea of permaculture education. It provides a yearlong PDC program in Asheville. This program features in-depth learning of sustainable agriculture and systematic teaching of ecology. The one-year program includes residency learning on a farm in Asheville, an online course, and traveling projects (The Permaculture School, 2014). The tuition fee for this course is not advertised.

For the Permaculture Design Certificate, other competitors in North Carolina, South Carolina and Virginia include Garner's Green, Gather and Grow, Surplus Permaculture Design, and The Blue Ridge Permaculture Network. These are NGOs that provide a PDC program in nearby regions with a similar course setting. In addition, both North Carolina State University and Duke University offer free PDC course material online.

## Financial Analysis

The Patterson School has been experiencing financial burdens, and according to its financial reports from 2012 to 2015, the average net income of the school each year is around 123,856 dollars. Our proposed strategies include renewable energy construction and developing educational curriculums that can build a sustainable campus brand for the Patterson School, while bringing the school considerable profits. A detailed summary of the costs and benefits of the proposed strategies are displayed in **Figure 5** (Appendix A1). As can be seen from the figure, educational programs will be the largest income generator for the Patterson School.

To estimate the potential revenue from the proposed projects, we modeled the potential cash flow of wind, solar, and small-scale educational programs. The aggregated cash flow in **Figure 6** (Appendix A1) was modeled based on the following conservative assumptions:

- Operation costs for the wind turbine are $40 each year, based on the calculated O&M costs for small scale wind turbines (Wind Measurement International, 2015).
- Operation costs for solar panels are $0 per year, since the PVWatts model already includes this cost and has discounted it back to the first year.
- PDC set up cost: $5,000, including all accommodations, refurbishing costs, marketing and recruiting.
- PDC operation cost: 50% of the PDC revenues
- REC set up cost: $5,000, including all accommodations, refurbishing costs, marketing and recruiting.
- REC operation cost: 50% of the REC revenues
- Initial student number for the courses: 10 persons per course
- The student growth rate for the courses: 20 percent per year until capacity is reached.
- The capacity for PDC: 20 persons per year (2 terms each year at 10 persons per course)
- The capacity for REC: 35-45 persons per year (3 to 4 terms each year at 10 persons per course)
- The price of the course: average market price
- The number of students: market number
- The original net income and electricity bill of Patterson School is not included.

As we can see cash flows will be positive from the first year of operation, and will increase through the seventh year. This is due to the assumption that the number of students will grow at a rate of 20 percent per year, bringing more revenue each year. From the eighth year, the cash flow will be steady. This is due to the assumption that the number of students will stop growing when the capacity is reached. The model projects a considerable positive cash flow for the whole project. To further evaluate the financial performance of this project, we calculated the simple payback period at a rate of 6 percent. If no discount rate is applied, the payback period for the initial investment would be three years. With the applied discount rate, the payback period is three and a half years.

Compared to the original payback periods of wind and solar, 68 and 45 years respectively, adding the educational programs has greatly shortened the payback period. By combing the small renewable energy projects with the educational programs, our recommendation is found to be financially feasible. Though the project can sustain itself from the third year of operation, the initial investment is still large. To address this problem, research on external opportunities to fund the projects was done.

## Funding Opportunities

The financial status of the Patterson School requires funding in order to support the construction of small-scale renewable energy projects as well as the initial setup of the PDC and REC courses. According to our research, funding opportunities for small-scale renewable businesses and green education are available from the federal government, state agencies and private parties. Some potential funding opportunities are listed below. Refer to **Table 8** for the full recommendation list.

**Grant: Southern SARE Sustainable Communities Innovations Grant (SCIG) Program**

Sustainable Agriculture Research and Education (SARE) offers a grant of 10,000 dollars to any individual or organization with innovative ideas that link the concepts of sustainable agriculture and a greener community.

The Sustainable Patterson proposal is eligible to apply for this grant by providing an innovative way to promote sustainable agriculture and renewable energy at the same time. What's more, the Patterson School as an NGO is giving back to its community by offering the PDC and renewable energy courses.

Application Timeline: Proposal due in October – Grant awarded in December.

**Grant: Cedar Tree Foundation**

The Cedar Tree Foundation offers a grant of up to 100,000 dollars to individuals, NGOs and small start-ups working in Environmental Education, Environmental Health, and Sustainable Agriculture in the United States.

The Sustainable Patterson proposal is eligible to apply for this grant by demonstrating their commitment to environmental education through permaculture and sustainable studies.

Application Timeline: Rolling basis, no deadline.

**Grant: The International Paper (IP) Foundation**

The International Paper Foundation provides a grant of 5,000 to 10,000 dollars to support non-profit organizations for environmental education in regions where International Paper has a presence in the community. The International Paper Foundation also requires the involvement of employee volunteers in this grant program.

The Sustainable Patterson proposal is eligible to apply for this grant by demonstrating their environmental education efforts toward permaculture and sustainable studies. The International Paper Foundation has a presence in Raleigh.

Application Timeline: Review of proposals occurs on a quarterly basis.

## 5. Recommendations

The first thing that the Patterson School Foundation needs to do should they wish to follow our recommendations is to increase the sustainability of their organization. We recommend that the Patterson School start by installing small scale renewable energy systems on their property. The renewable energy technologies should include wind and roof top solar. More specifically, a small wind turbine rated at 1 kilo-watt should be installed on the roof of the building that is the most accessible to future students. This will allow students to access the wind turbine and gain a hands-on understanding of wind power. The same process should be pursued for solar panels.

It should be mentioned that renewable energy is primarily strategic in nature. These projects offer little economic benefit by themselves. However, there are several benefits to installing small scale wind and rooftop solar at the Patterson School. The primary benefit is that these two green energy technologies will ultimately lower the carbon intensity of the Patterson School. The Patterson School Foundation will thus be able to demonstrate to potential patrons that the school is committed to fostering a more sustainable status quo. Ensuring customers that Patterson is sustainable, or at least transitioning toward sustainability, is essential. Customers will want to learn about sustainability from knowledgeable practitioners of sustainable development. Installing renewable power systems is one of many ways in which Patterson can demonstrate that they are sustainability practitioners. Many renewable energy systems are immediately recognizable even to those who are not familiar with sustainability.

Additionally, we recommend that the Patterson School implement small format classes with an initial focus on permaculture and renewable energy. Specifically, we would recommend that the Patterson School pursue full PDC certification. This allows for the courses to be advertised using the Permaculture moniker. Additionally, the PDC could allow for long term development of the Patterson School's property. One of the requirements for teaching a PDC course is that students engage in the construction of a permaculture system. Patterson could use this requirement to have students develop their lands over time. Furthermore, we recommend that the Patterson School offer two different curriculums to accommodate for students' needs: the summer/winter weekday workshops and the weekend workshops.

The renewable energy course should be pursued because it would allow the Patterson School to utilize their renewable energy installations. Renewable energy courses have the advantage of being somewhat modular in nature. The Patterson School should start with a basic course that serves as an introduction to renewable energy. Then, as time allows, the school can pursue more advanced courses that build off the first.

Beyond the permaculture and renewable energy courses there are a variety of small format educational courses the Patterson School could create. These classes can be created as demand grows. This is where the Patterson School will see the benefits of small format education. If an offered class does not perform well the course can either be scaled back or abandoned without significant loss of time or money.

# 6. Discussion

## Large scale renewable energy development

Initially, development of large scale renewables seemed like an ideal plan for the Patterson School. Abundant land and a theoretical understanding of renewables suggested that large scale renewable development should be possible at Patterson. To determine whether large scale renewable energy systems were feasible we conducted an in-depth natural resource assessment at the Patterson School. Upon further investigation our assumptions did not hold.

A legal analysis revealed that large scale wind turbines could not be deployed on the mountain ridges of the Patterson School, where wind speeds are typically greatest. Additionally, wind turbines with power ratings higher than 20 kilowatts are regulated by the state government. This practically limits the Patterson School to small scale wind production in the valley. Wind data suggests that wind speeds in the valley are low. Indeed, wind speeds of zero miles per hour were reported nearly 25 percent of the time. Furthermore, the average wind speed that is to be expected at the Patterson School is 3.89 miles per hour which is less than the cut in speed of even the most efficient turbines on the market. Therefore, even relatively inexpensive and small scale wind projects have a negative net present value. From a purely economic perspective, wind power should not be pursued at the Patterson School. Small scale wind power also has an insignificant effect on the overall sustainability of the property. The carbon savings from the modeled wind turbine reduce the yearly carbon dioxide emissions from the Patterson School by less than one percent.

Large scale solar development was hindered for one primary reason. The Patterson School is hesitant to use fertile valley land for the deployment of large scale solar power. This hesitation seems to be well placed. An analysis revealed that installing photovoltaic panels on six roofs at the Patterson School generates very little cash flow. The simple payback period of the project would be 46 years. Additionally, the value of the project as a whole is negative when a discount rate is applied. However, rooftop solar offers significant benefits toward the overall sustainability of the school. If all six of the modeled buildings installed solar panels it could cut the yearly carbon emissions nearly in half.

Restoring the dam to develop hydroelectric power was also investigated. Hydroelectric power had reasonable economic performance. A quick analysis revealed that the simple payback period of restoring the dam was 12.5 years. However, the costs to engage in the project are currently prohibitively high. The dam also faces legal challenges that could take significant funding and time to address. However, if the size of the restoration project is small enough it would qualify for exemptions and may not have to be licensed by federal and state agencies. As such this project may make more sense in a few years once the Patterson School is better funded.

Quite simply, large scale renewable power generation is not appropriate for the Patterson School from an economic perspective. The costs are too great and the payback periods are prohibitive. However, there are still benefits to be gained from installing small scale renewable power projects. The primary benefit of small scale renewable energy at the Patterson School is that it will increase the overall sustainability of the foundation. This increase in sustainability would result in lowering the Patterson School's carbon footprint. It is important for the Patterson School to lower their carbon emissions and increase their perceived sustainability in general. If Patterson is to offer classes and services based on sustainability it is key that patrons perceive the foundation as being sustainable. At a minimum, the Patterson School Foundation needs to convince customers that the school is transitioning towards greater sustainability.

## Small Format Education

The main way the Patterson School can leverage their physical capital is through the development of small format classes. Small format classes allow the Patterson School to utilize buildings that are currently nonproductive. The Patterson School also has a strong educational background. Therefore, they have experience designing course curriculum and finding talented educators to lead courses. Additionally, we have seen many instances of small format classes teaching similar subjects being successful elsewhere in the state. As a starting point we recommend two types of classes: a class on permaculture, and a class on renewable energy.

The permaculture class is especially attractive to the Patterson School because they can work with enrolled students to continue to develop their land. One of the requirements for teaching a PDC course is that students engage in the construction of a permaculture system. The Patterson School could use this requirement to develop their own lands over time. If done correctly, developing the land through the permaculture course could create additional economic cash flows.

The renewable energy course will allow the Patterson School to demonstrate their wind and solar installations. As mentioned earlier the wind turbine and solar panels are primarily a strategic plan to increase the overall sustainability image of the Patterson School. Planning a course around them will help to recover the costs of the solar and wind system installations in the short run. Our analysis suggests that the payback periods could drop significantly with the help of these courses. Wind could have payback periods ranging from less than a year up to two years. Solar could have a payback period between 5 and 18 years.

The Patterson School has two possible formats in which they could offer their courses. The courses should either be technical more general in nature. Earlier in this analysis we discussed several case studies of competing organizations that exemplify both technical course offerings and general course offerings. Each format has benefits and potential drawbacks.

The main benefit afforded by more technical classes is that they command a higher price point. This is due to the fact that more technical classes have to be taught over longer periods of time and demand highly knowledgeable instructors. Additionally, more technical classes serve a smaller customer base. As such, highly technical courses are taught less frequently.

Courses that are more general in nature offer several benefits. Content that is more general allows for a broader audience, a wider instructor pool, and diversified courses. This allows the courses to be taught frequently throughout the year. Offering a diverse course selection is beneficial in two ways. First, it allows for repeat students. Secondly, it allows the Patterson School to determine demand for each course. Thus, courses with higher demand can be taught more frequently and courses with more niche appeal can be taught only a few times each year. The drawback of general courses is that they command a lower price point. This requires that the Patterson School offer classes frequently to maintain strong cash flows.

### Strategic Partnerships and Interns

Creating high quality short term educational classes could take up valuable time and resources. For these reasons, we recommend that the Patterson School utilize interns to help develop, design, and teach courses at the Patterson School. Patterson could offer the intern a room at Palmyra Hall for the summer. This would allow the intern to have in depth access to the property so that the curriculum of the course could be tailored specifically to the Patterson School. Additionally, students could lead these courses as part of their internship.

Interns have been shown to be quite useful in creating and leading courses of this nature. First, consider Pickards Mountain Eco Institute. The PMEI model is successful for several reasons. First, they keep overhead low by encouraging volunteers and offering internships. In this way work can be done on the property at minimal cost. Patterson would be wise to offer internships in a similar manner. Interns could create curriculum for a designated class, teach classes throughout the summer, or even manage a new project such as beekeeping or setting up a mycology course.

Utilizing interns should be a key strategy for the Patterson School Foundation. They can offer unique opportunities to develop and teach courses at the Patterson School. Ideally, the students would be pursuing a degree in a sustainability related field. Schools where such students can be found include the Nicholas School of the Environment at Duke University and the Sustainable Development and Appropriate Technology programs at Appalachian State University.

## 7. Conclusion

We believe that the strategies discussed in this analysis can be used to start the Patterson School Foundation down a path of greater sustainability. We have chosen projects that will increase the overall environmental sustainability of the Patterson School. We specifically recommend sustainability projects that are highly recognizable to attract potential customers. These projects also offer a clear path of economic development for the Patterson School. Furthermore, initiatives were chosen in an attempt to utilize as much of the Patterson School's existing assets as possible. For these reasons, we recommend that the Patterson School Foundation consider these recommendations as future development strategies.

# Appendix

## A1. Figure Appendix

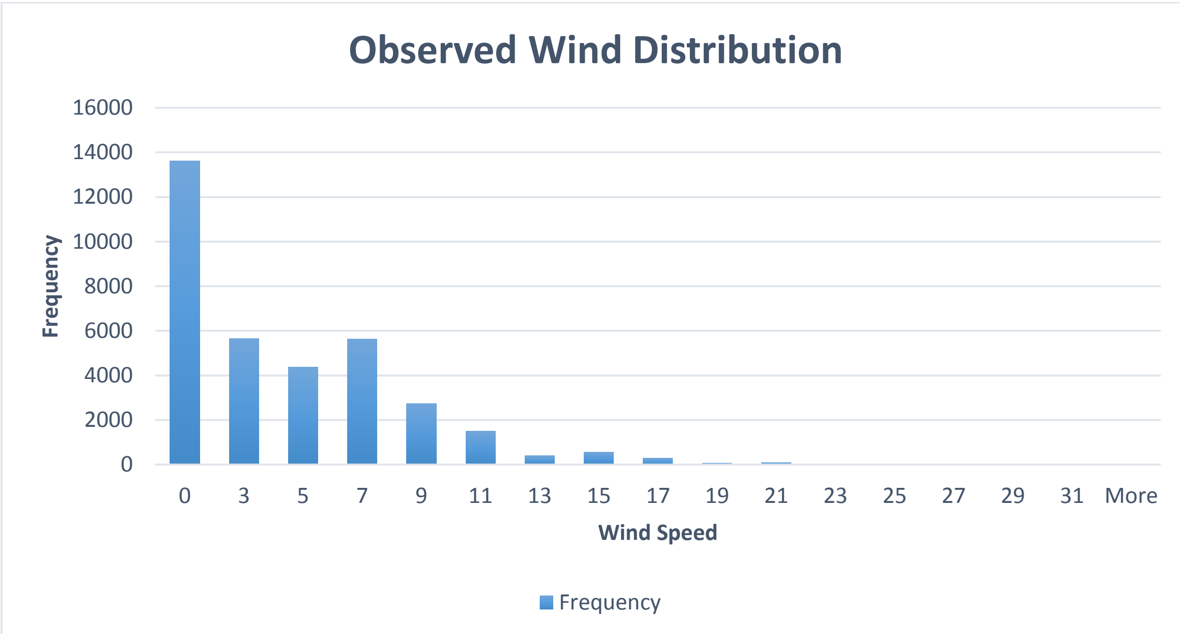


**Figure 1: Distribution of observed wind speeds in Miles per Hour**

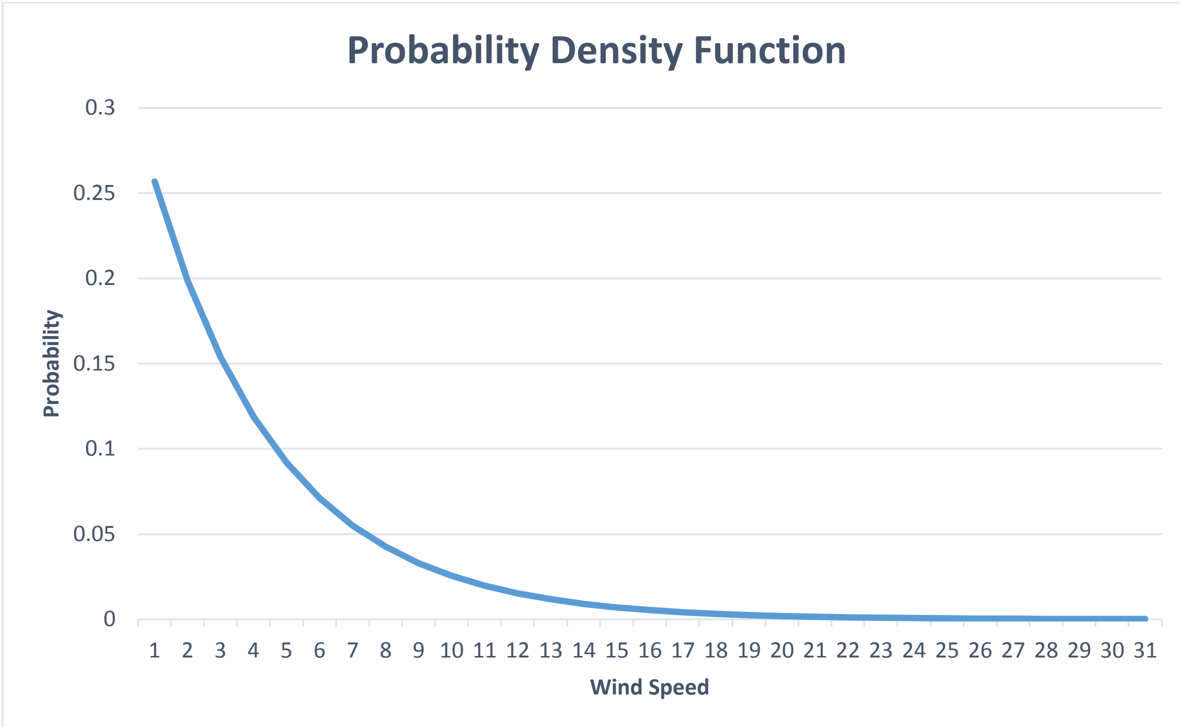


**Figure 2: Probability Density Function**

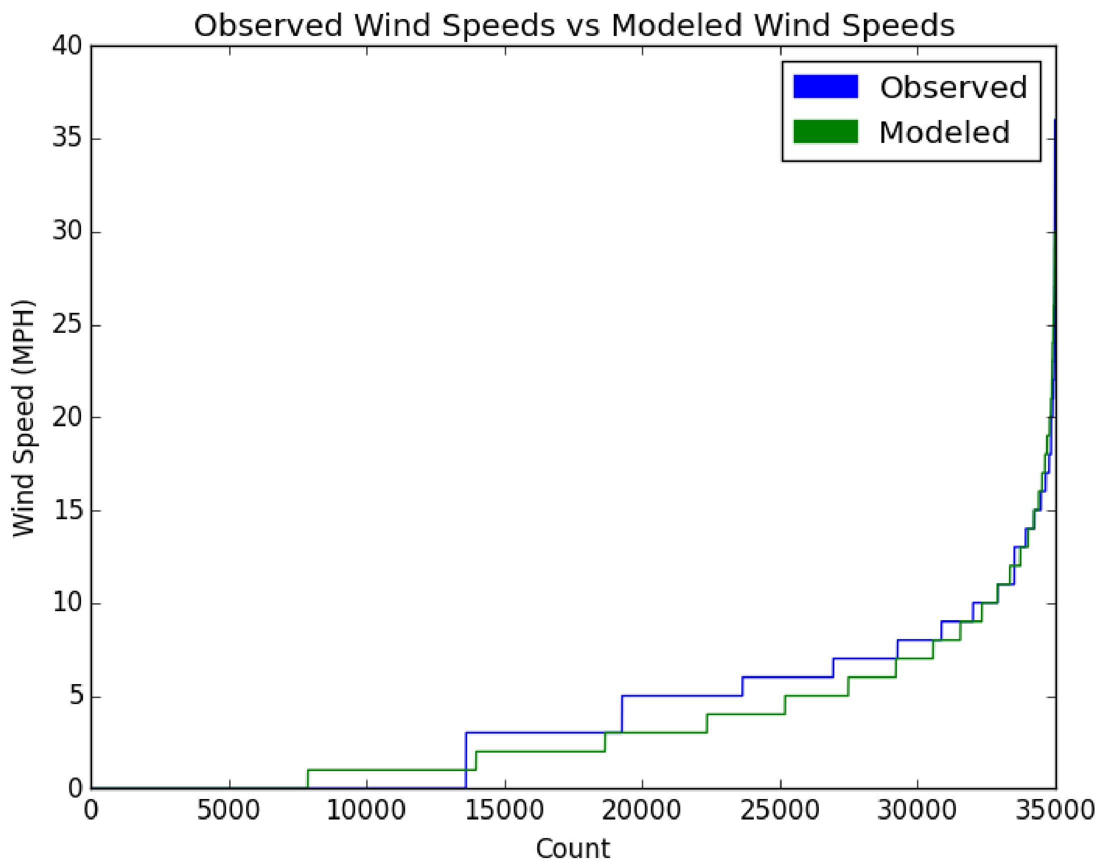


**Figure 3:** **Shows counts of modeled wind speeds against observed wind speeds.**


**Figure 4: Shows the buildings of the Patterson School selected for solar panel installation.**

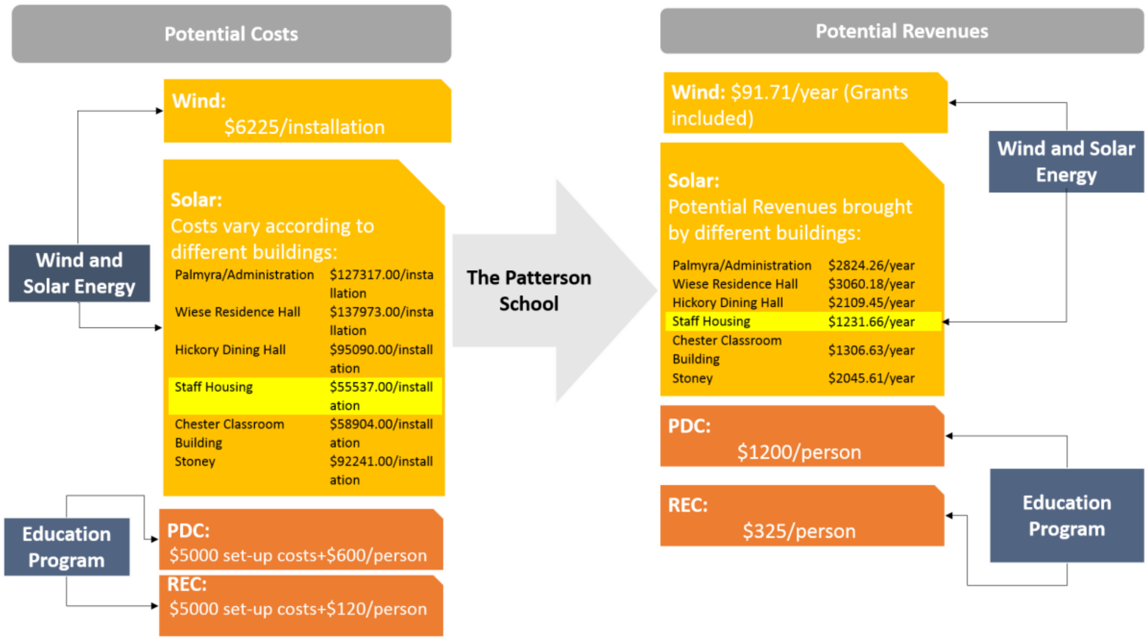


**Figure 5: Costs and Benefits Summary of Proposed Strategies**

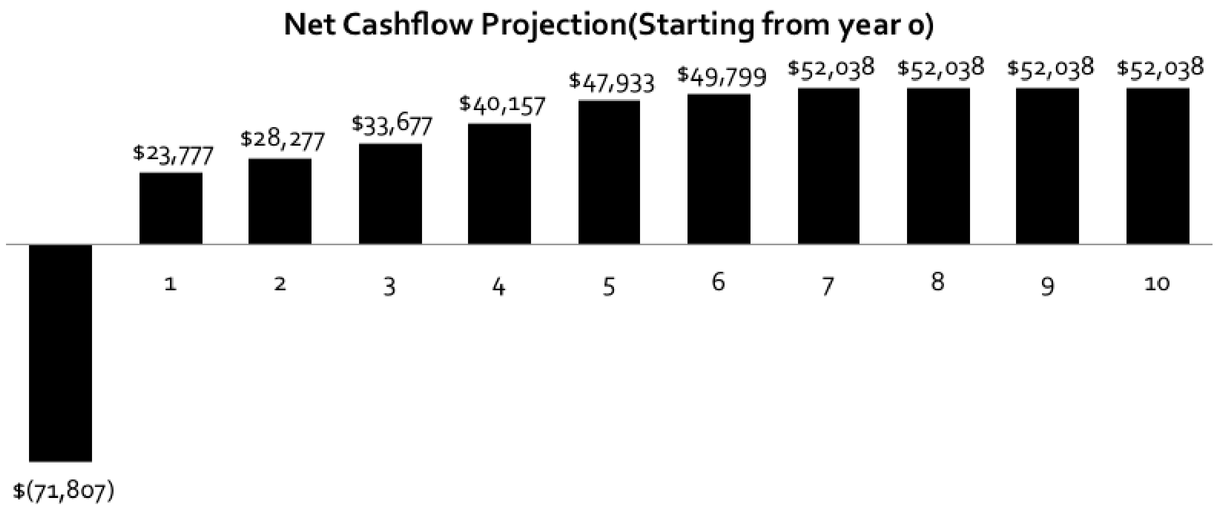


**Figure 6: Net Cash Flow Projection**

| Payback Period(Not discounted ) | | | |
|---|---|---|---|
| Year | Beginning Balance | Net Cash Flows | Ending Balance |
| 0 | -$71,698 | $0 | -$71,698 |
| 1 | -$71,698 | $23,841 | -$47,857 |
| 2 | -$47,857 | $28,341 | -$19,517 |
| 3 | -$19,517 | $33,741 | $14,224 |
| Payback Period = | | 3 | Years |

| Payback Period(Discounted) | | | |
|---|---|---|---|
| Year | Beginning Balance | Net Cash Flows (discounted) | Ending Balance |
| 0 | -$71,698.00 | $0.00 | -$71,698.00 |
| 1 | -$71,698.00 | $22,491.19 | -$49,206.81 |
| 2 | -$49,206.81 | $25,223.09 | -$23,983.72 |
| 3 | -$23,983.72 | $28,329.31 | $4,345.58 |
| Discounted Payback Period = | | 3.5 | Years |

**Figure 7: Payback Period**

## A2. Table Appendix

| Building Name | Roof Area ($m^2$) | Actual Area for Installation ($m^2$) | DC System Size (kW) | Generation per year (kWh/year) |
|---|---|---|---|---|
| **Palmyra/Administration** | 458.85 | 229.43 | 34.41 | 45,923.00 |
| **Wiese Residence Hall** | 497.18 | 248.59 | 37.29 | 49,759.00 |
| **Hickory Dining Hall** | 342.72 | 171.36 | 25.7 | 34,300.00 |
| **Staff Housing** | 200.1 | 100.05 | 15.01 | 20,027.00 |
| **Chester Classroom Building** | 212.28 | 106.14 | 15.92 | 21,246.00 |
| **Stoney** | 332.34 | 166.17 | 24.93 | 33,262.00 |
| **Total** | | | | 204,517.00 |

**Table 1: Results of Solar model**

| Building Name | DC System Size (kW) | Generation per year (kWh/year) | Costs ($) | Potential Revenues ($) | Stable Net Profits ($) |
|---|---|---|---|---|---|
| Palmyra/Administration | 34.41 | 45,923.00 | 127317 | 2824.26 | -77435 |
| Wiese Residence Hall | 37.29 | 49,759.00 | 137973 | 3060.18 | -83904 |
| Hickory Dining Hall | 25.7 | 34,300.00 | 95090 | 2109.45 | -57837 |
| Staff Housing | 15.01 | 20,027.00 | 55537 | 1231.66 | -33768 |
| Chester Classroom Building | 15.92 | 21,246.00 | 58904 | 1306.63 | -35823 |
| Stoney | 24.93 | 33,262.00 | 92241 | 2045.61 | -56085 |

**Table 2: Costs and Revenues of Photovoltaic Panels on the Six Buildings**

| Generation Source | Percent of Total Generation |
|---|---|
| Non-Hydro Renewables | 2% |
| Hydro | 2% |
| Nuclear | 38% |
| Oil | 1% |
| Gas | 12% |
| Coal | 46% |

**Table 3: Electricity generation profile for power purchased from Blue Ridge Electric. Based on area code 28645. Information from US EPA Power Profiler.**

| Building Name | Generation per year (kWh/year) | Carbon Savings (tons/year) |
|---|---|---|
| Palmyra/Administration | 45923 | 24.7 |
| Wiese Residence Hall | 49759 | 26.7 |
| Hickory Dining Hall | 34300 | 18.4 |
| Staff Housing | 20027 | 10.8 |
| Chester Classroom Building | 21246 | 11.4 |
| Stoney | 33262 | 17.9 |

**Table 4: Carbon dioxide savings from installation of solar panels by building**

| | |
|---|---|
| Day 1 | **The idea of sustainable living:**<br>Class Content<br>• Introduction to permaculture (100 minutes)<br>• Syllabus and brief about PDC (40 minutes)<br>• Break (10 minutes)<br>• Land Mapping (60 minutes)<br>• Break (10 minutes)<br>• PDC Principles (80 minutes)<br>• Class Length: 5.0 hrs<br>• Location: Classroom |
| Day 2 | **Permaculture in Agriculture**<br>• Ecological pest management (75 minutes)<br>• Vegetarian and organic food (65 minutes)<br>• Break (10 minutes)<br>• Gardening (30 minutes)<br>• Organic Fruits (90 minutes)<br>• Class Length: 4 hrs, 30 minutes<br>• Location: Classroom |
| Day 3 | **Gardening Practice I**<br>• Earthworks and the garden (90 minutes)<br>• Irrigation (90 minutes)<br>• Lunch (60 minutes)<br>• Planting a tree (180 minutes)<br>• Breaks (30 minutes)<br>• Class Length: 8.0 hrs<br>• Location: Patterson Farm |
| Day 4 | **Gardening Practice II**<br>• Looking at potential garden sites— breakout groups (180 minutes)<br>• Lunch (60 minutes)<br>• Design work, presentations & choosing a site (150 minutes)<br>• Construction (120 minutes)<br>• Class Length: 8.0 hrs<br>• Location: Patterson Farm |
| Day 5 | **Transit to a Smart Patterson Farming System**<br>• Land development (90 minutes)<br>• Transition initiative (30 minutes)<br>• Break (10 minutes)<br>• North Carolina initiatives (30 minutes)<br>• Water (60 minutes)<br>• Class Length: 4.0 hrs<br>• Location: Classroom |
| Day 6 | **Smart House Tour**<br>• Class Length: 4.0 hrs |

| | |
|---|---|
| | • Location: Duke University and Patterson Smart House |
| Day 7 | **Sustainable Community**<br>• Bioregional organizations for sustainable communities (30 minutes)<br>• Alternative economics (60 minutes)<br>• Break (15 minutes)<br>• Household pests (15 minutes)<br>• Placing the house and design for disaster (60 minutes)<br>• Class Length: 3.0 hrs<br>• Location: Patterson Smart House |
| Day 8 | **Natural Resources**<br>• Mapping & placement (50 minutes)<br>• Water supply & natural purification (60minutes)<br>• Renewable Energy (120 minutes)<br>• Break (10 minutes)<br>• Natural building (60 minutes)<br>• Class Length: 5.0 hrs<br>• Location: Patterson Smart House |
| Day 9 | **Eco-House**<br>• Climate and the ecohouse (60 minutes)<br>• Eco architecture (90 minutes)<br>• Integral urban home concept (30 minutes)<br>• Hands on designing the eco-house in small groups (60 minutes)<br>• Class Length: 4.0 hrs<br>• Location: Patterson Smart House |
| Day 10 | **Permaculture Community**<br>• Building community neighborhood by neighborhood (120 minutes)<br>• Lunch (60 minutes)<br>• Hands on Renewable Energy (240 minutes)<br>• Class Length: 7.0 hrs<br>• Location: Patterson Farm |
| Day 11 | **North Carolina Ecosystem**<br>• Ecology, restoration ecology<br>• Class Length: 5.0 hrs<br>• Location: Classroom |
| Day 12 | **Design Project and Graduation** |

**Table 5: PDC Curriculum Design**

| | |
|---|---|
| **Basics of Electricity** | • What is electricity<br>• Alternating and Direct Currents (AC/DC)<br>• Power and Energy |
| **Solar Power** | • How solar systems work<br>• Solar Panel Technology (mono crystalline, polycrystalline, and thin film) and the benefits and weaknesses of each.<br>• Intermittency of solar<br>• Mounting a solar system<br>• Orientation, seasonality, and power output (insolation) |
| **Wind Power** | • How wind turbines work<br>• Intermittency<br>• Wind power formula<br>• Wind speed increases with height<br>• Turbine models (horizontal and vertical orientation) and the benefits and weaknesses of each. |
| **Economics of renewables** | • Where to get wind and solar data<br>• Basic modeling to predict power production (from scratch and using preexisting tools such as PVWatts)<br>• Calculating system sizes<br>• Grants, tax breaks, and other economic incentives |
| **Legal** | • Legal considerations<br>• Zoning requirements<br>• Net Metering |

**Table 6: REC Curriculum Design**

| | Institute Name | Course | Cost | # of Students | location | Contact | Link/Source |
|---|---|---|---|---|---|---|---|
| North Carolina | **Living System Design** | Permaculture Design Certification January-March 2014 @ Earthhaven Ecovillage | 900~1300 | 20-30 | Bellavia Circle, Black Mountain NC 28711 | (828)669-1759 | http://www.livingsystemsdesign.net/ |
| | **We Are All Farmers** | On-the-Farm Permaculture Design Certificate Course | 750-850 | 10-15 | Union Grove, NC | weareallfarmers@gmail (704)592-2557 | http://weareallfarmers.org/tag/permaculture-design-certificate-north-carolina/ |
| | **Wild Abundance** | A place-based Permaculture Design Course at home in southern Appalachia: September 12-13, 2015 | 950~1250 | 30 | Chinquapin Hill (20 minutes north of Asheville) | info.wildabundance@gmail.com (828)775-7052 | http://wildabundance.net/?page=pdc2014 |
| | **The Permaculture School** | Permaculture Schoo full program: Design Ecology & Living Skills | NA | NA | Asheville, NC | Sam@ThePermacultureSchool.org | http://thepermacultureschool.org/ps/ |
| | **Spiral Ridge** | Permaculture Design Course | 1675 | 10-15 | 3200 Little Creek Road Hot Springs | (931) 231-4099 | http://www.spiralridgepermaculture.com/events/permaculture-design-certificate-course/ |
| | **Garner's Green** | Permaculture Design Course | 500 | 20-30 | Carrboro | grow@yardsprout.com (919) 360-2028 | http://www.yardsprout.com/listings/permaculture-design-course-carrboro-nc/ |
| South Carolina | **Gather and Grow** | SOUTH CAROLINA PERMACULTURE DESIGN COURSE | 925 | 30 | Columbia, SC | sustainablesouth@hotmail.com | http://www.matthewkip.com/south-carolina-permaculture-design-course.html |
| | **Surplus Permaculture Design** | PDC | 825 | 20-30 | Charleston, SC | Surpluspermaculturedesign@gmail.com | http://www.surpluspermaculture.org/weekend-permaculture-design-certification-72-hour-course-spring-2015/ |
| Virginia | **The Blue Ridge Permaculture Network** | Permaculture Design Course | 895-1200 | 15-20 | Charlottesville, Virginia | tygerlilley@gmail.com | http://www.blueridgepermaculture.net/courses.html |
| Online Source | **North Carolina State University** | Permaculture Design Course | 0 | NA | Online | Will Hookers | http://mediasite.online.ncsu.edu/online/Catalog/Full/f5a893e74b7c4b7980fd52dcd1ced71521 |
| | **Duke Univeristy** | Permaculture Design Course | 0 | NA | Online | Toby Hemenway - Permaculture Lecture at Duke: | http://www.youtube.com/watch?v=8nLKHYHmPbo |

**Table 7: List of Potential Competitors**

| Organization | Category | $ Amount | Application Criteria | Contact | Link/Source |
|---|---|---|---|---|---|
| Southern SARE: Sustainable Communities Innovations Grant (SCIG) Program | Grants | $10,000 | “Any person or organization with an idea that will link sustainable agriculture activities to healthy rural community development.” | http://www.southernsare.org/About-Us/Contact-Staff | www.southernsare.org/Grants/Types-of-Grants/Sustainable-Community-Innovation-Grants |
| Cedar Tree Foundation | Grants | 100,000 | “General Public, Non-formal Educators, Teachers. Concerning areas: environmental education, environmental health and sustainable agriculture. Particular consideration is given to proposals demonstrating strong elements of environmental justice and/or conservation within the program areas listed above.” | http://www.cedartreefound.org/SustainableAgriculture2012.html | http://www.cedartreefound.org/apply.html |
| The International Paper (IP) Foundation | Grants | 5,000-10,000 | “Supports non-profit organizations in communities where its employees live and work. Environmental education is one of the primary areas the Foundation supports.” | IPFoundation@ipaper.com | http://www.internationalpaper.com/US/EN/Company/IPGiving/ApplicationGuidelines.html |
| World We Want Foundation | Grants | NA | “Supports youth making positive social change in their communities and around the world. The Foundation works with and through the partner organizations and mentors that applicants provide, helps young people design and conduct meaningful social action projects, provides micro-grants to support projects, and more.” | | http://theworldwewantfoundation.org/ |
| Captain Planet Foundation | Grants | 500-2500 | “School and community groups to support hands-on environmental projects.” | http://www.captainplanetfoundation.org/contact-us/ | http://www.captainplanetfoundation.org/apply-for-grants/ |
| NOAA Environmental Literacy | Grants | 250,000-500,000 | “K-12 schools and others to develop projects to strengthen environmental literacy with the goal of improving community resilience to extreme weather events and environmental change” | http://www.grants.gov/web/grants/about/contact-us.html | http://www.grants.gov/web/grants/search-grants.html |
| ShadeFund | Loan | 20,000-50,000 | “Existing small businesses that are involved in the responsible use of farmland and forestland:<br><br>sustainable or organic farming;<br>sustainable forestry and forest products;<br>eco-tourism;<br>natural food and medicines;<br>small-scale biomass;<br>renewable energy and energy efficiency.” | (919) 951-0113 | www.shadefund.org/entrepreneurs/become-an-entrepreneur.htm |
| Self-Help Credit Union / Carolina Mountains Credit Union (CMCU) | Loan | 100,000+ | “Borrowers need to show a history of successful business development, experienced management, solid cash flow projections, as well as collateral to help secure the loan (although there are other programs to help, such as the SBA 7a program, if collateral is the loan’s only major weakness).” | nikia.sharp@self-help.org | www.self-help.org |
| Carolina Farm Credit | Loan | NA | “Must be a farmer, or rural resident to obtain a loan from Carolina Farm Credit, ACA. All loans are underwritten on their individual merits, within the bounds of the Association’s Credit Policy.” | | www.carolinafarmcredit.com/cfc3/loans-agloans.asp?tabpage=AGLOANS&ucliked=Ag%20Loans |
| USDA Rural Development: Business and Industry | Loan | max 10 Mn | “Cooperatives, non-profit organizations, corporations, partnerships, or other legal entities; Indian tribes; public bodies; or individuals. A borrower must be engaged in or proposing to engage in a business that | http://www.rurdev.usda.gov/recd_map.html. | http://www.usda.gov/wps/portal/usda/usdahome?con |

| | | | | | |
|---|---|---|---|---|---|
| Guaranteed Loans (B&I) | | | will:<br><br>Provide employment;<br>Improve the economic or environmental climate;<br>Promote the conservation, development, and use of water for aquaculture; or<br>Reduce reliance on nonrenewable energy resources by encouraging the development and construction of solar energy systems and other renewable energy systems." | | tentid=kyf_grants_rd3_content.html |
| NC Rural Center: Microenterprise Loan Program | Loan | $500-$25,000 | "Work with individuals who have sound ideas for starting or expanding a small business but may not qualify for bank credit. Farms, food businesses and others in rural NC are encouraged to apply." | 919-250-4314. | http://www.ncruralcenter.org/index.php?option=com_content&view=article&id=82&Itemid=217 |
| USDA: Rural Business Enterprise Grant (RBEG) | Grants | $10,000 to $500,000 | "Local and state governments and authorities, Indian tribes and non-profit organizations are eligible to reply." | http://www.rurdev.usda.gov/recd_map.html. | http://www.usda.gov/wps/portal/usda/usdahome?contentid=kyf_grants_rd6_content.html |
| USDA Rural Development: Rural Energy for America Program (REAP) | Grants | NA | "Agricultural producers and rural small businesses. To be eligible, you must be actively involved in the business and the proposed project." | David.Thigpen@nc.usda.gov. | www.rurdev.usda.gov/BCP_Reap.html |

**Table 8: List of Funding Opportunities**

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